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# TECHNICAL TRANSLATION

F-50

INTERNATIONAL GEOPHYSICAL YEAR INFORMATION

BULLETIN, NO. 7

Translated from compilation made under the auspices of the Interdepartmental Committee for the Conduct of the International Geophysical Year, Under the Presidium of the Academy of Sciences of the USSR; printed by the Publishing House of the Academy of Sciences, USSR (Moscow), 1959

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON November 1960

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CONTENTS

# THE DEPENDENCE OF THE FREQUENCY OF APPEARANCE OF NOCTILUCENT CLOUDS UPON THE DATE AND THE GEOGRAPHICAL LATITUDE

By V. V. Sharonov

One of the peculiarities of noctilucent clouds is the distribution of their appearance by seasons and latitudes. As is well known, they never appear in the winter and are observed only in a restricted zone of latitudes extending roughly from the 45th parallel to the Polar Circle. These curious facts were established as a result of a small number of chance observations made by individual volunteer observers in different countries. The material acquired in this manner does not meet the requirements of scientific climatology. Up to this time, regular observations of noctilucent clouds had not been made anywhere.

In the course of planning observations of noctilucent clouds during the International Geophysical Year, provision was made first of all for obtaining data which would pinpoint the distribution of these formations in time and space. Obtaining projections of the clouds on a map of the earth's surface is the most modern form of such studies. Such observations are being carried out, but on an inadequate scale. For the time being, therefore, only the results of the most simple observations, consisting of recording the fact of the appearance of noctilucent clouds in the sky, can be utilized for statistical processing.

In order to compile a preliminary judgment on those bounds in time and space which determine the possibility of the appearance of noctilucent clouds, the processing of observations carried out in the USSR and published in the press was undertaken. The work on the selection of bibliography and the results of observations was done by L. F. Gromova. The extensive bibliographic material was placed at our disposal by the Scientific Secretary of the Committee on Meteorites of the Academy of Sciences, USSR, Ye. L. Krinov.

After doubtful and incomplete observations were excluded, also all data referring to 30 June 1958, 369 cases of recorded appearances of noctilucent clouds remained. These data do not represent exhaustive completeness. Their distribution by ten-day periods and by 5-degree latitudinal zones are given in the left half of the table presented here. Of course, this material falls far short of presenting the actual distribution of noctilucent clouds by date and latitude inasmuch as it is biased by different sources of selection. However, it may be used for obtaining more reliable results.

Let the total number of appearances of noctilucent clouds, noted during preceding years, which are recorded during a given ten-day period in a given month and in a given zone of latitude be N. As a rough first approximation, we can assume that it is proportional to the true frequency of the appearance of noctilucent clouds h, the duration of the time interval during which noctilucent clouds can be seen according to the conditions of their illumination, the probability P of cloudiness during this time, and still another factor Q which is determined by the number of active observers and the intensiveness of their work:

$$N = khtPQ \tag{1}$$

where k is the proportionality coefficient.

In order that even approximate values of h can be obtained in accordance with available values of N, it is essential to evaluate somehow the remaining parameters of this formula.

It is simplest of all to calculate values for t. Assuming that the time of possible visibility of noctilucent clouds coincides with navigational and astronomical twilight, we can make use of data published in Tablitsakh dlya rascheta prirodnoy osveshchennosti i vidimosti [Tables for the Calculation of Natural Illumination and Visibility] [1].

| Month | Ten-Day Period | Initial Data 45° | 50° | 55° | 60° | Total | Reduced Data 45° | 50° | 55° | 60° | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IV | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 7 | 7 |
| | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 5 | 5 |
| V | 1 | 0 | 0 | 2 | 1 | 3 | 0 | 0 | 11 | 6 | 17 |
| | 2 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 15 | 0 | 15 |
| | 3 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 11 | 0 | 11 |
| VI | 1 | 0 | 1 | 7 | 0 | 8 | 0 | 4 | 42 | 0 | 46 |
| | 2 | 0 | 2 | 22 | 5 | 29 | 0 | 9 | 125 | 95 | 229 |
| | 3 | 0 | 7 | 54 | 10 | 71 | 0 | 29 | 301 | 196 | 526 |
| VII | 1 | 0 | 11 | 75 | 10 | 96 | 0 | 43 | 488 | 134 | 665 |
| | 2 | 1 | 3 | 38 | 35 | 77 | 6 | 14 | 203 | 330 | 553 |
| | 3 | 0 | 1 | 17 | 30 | 48 | 0 | 5 | 85 | 224 | 314 |
| VIII | 1 | 1 | 0 | 4 | 16 | 21 | 7 | 0 | 16 | 148 | 171 |
| | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 13 | 0 | 13 |
| | 3 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 15 | 15 |

| Month | Ten-Day Period | Initial Data 45° | 50° | 55° | 60° | Total | Reduced Data 45° | 50° | 55° | 60° | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IX | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 9 | 0 | 0 | 9 |
| | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 11 | 0 | 11 |
| | 3 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 13 | 14 | 27 |
| X | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 13 | 0 | 13 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | | 2 | 26 | 229 | 112 | 369 | 13 | 113 | 1347 | 1174 | 2647 |

In order to obtain values for P, it was necessary to turn to climatological data whose use is all the more justified in our case as we are dealing with observations of noctilucent clouds which cover a 70-year period of time. We made use of maps of the probability of overcast weather compiled in accordance with observations over the period 1896-1915 and published in the Klimatologicheskiy atlac SSSR [Climatological Atlas of the USSR] [2]. Values of the probability of overcast sky, expressed in percentages, were taken from these maps along parallels corresponding to 45, 50, 55, and 60 degrees of latitudes for points of their intersection with the meridians corresponding to every 5 degrees in the interval from 25 to 80 degrees of longitude (in which almost all the observations we used were made). This provided 12 values for each parallel, which served as a basis for the mean value of the given parallel. This could be considered sufficiently representative for the given zone of latitude since the isonephs for the months of interest to us generally went along the geographical parallels. Additions to the numbers obtained, amounting to 100, were accepted as values of probability P for clear sky.

There were no suitable data at our disposal for evaluating the parameter Q; therefore, the only course open was to set Q 1, that is, to refrain from calculating the distribution of observers throughout the territory of the country. Finally, in order to obtain a convenient system of numbers, the value $10^{-4}$ was accepted for the arbitrary factor k.

In this manner, we obtain the formula for the practical calculation of the frequency of appearances of noctilucent clouds:

$$h = 10000\frac{N}{tP} . \qquad (2)$$

The results of the calculation are presented in the right portion of the table. Examination of these figures leads to the following conclusions.

1. The time that the noctilucent clouds appear includes the warm part of the year, from April to October, inclusive.

2. The reduced values of frequency, both the initial and the reduced values, show a maximum number of appearances of noctilucent clouds in the first half of July; in the 60-degree zone it is shifted over to the second ten-day period, which however may not be the actual situation.

3. The latitudinal zone in which noctilucent clouds were observed extended from 45 to 60 degrees, inclusive. The lack of noctilucent clouds at 40 degrees latitude and south can be considered a proven fact as the 40th parallel is characterized by a fairly dense population, the presence of large cities, observatories, and a large number of summer days with clear weather. In addition, some persons experienced in observing noctilucent clouds conducted special observations there which yielded negative results. On the other hand, it is not possible to consider a lack of cases of appearance of noctilucent clouds true of the 65-degree zone inasmuch as this zone is thinly populated and is not distinguished by clear skies.

4. Within the bounds of the aforementioned latitudinal zone, the frequency of appearance of noctilucent clouds grows initially with an increase in latitude, passes through a maximum at $\Psi = 55$ degrees, then breaks sharply, going to zero for the 65-degree zone. This last item is, as already stated, apparently not the real situation. It is noteworthy that the difference in frequency of the appearance of noctilucent clouds in the 55-degree and the 60-degree zones is very marked in the figures of the initial material (N is approximately halved), but almost disappears in the reduced figures. It is possible that the remaining difference should be ascribed to incompleteness of the reduction and, in the first place, to the effect of the factor Q.

In order to obtain complete freedom from the effect of the factor Q, it will be necessary to make the transition from chance observations made by volunteer observers to regular observations carried out by a rationally distributed network of stations. This is what was done in the USSR during the MGG [Mezhdynarodnyy Geofizicheskiy God — International Geophysical Year]. All meteorological stations of the MGG located between 45 and 70 degrees latitude recorded the appearance of noctilucent clouds every day at 15-minute intervals. There are 220 such stations in the USSR. If one assumes that observations are made with the same care at all stations, then the factor Q actually should be set equal to unity and the material obtained will possess the proper uniformity.

Formula (2), which expresses a solution of the problem that is good only to a first approximation, is already inadequate for processing the data. Noctilucent clouds are ordinarily quite variable in respect to both apparent size and brightness. Thus, depending upon the distribution of the clouds in duration and intensity, the number of appearances noted will change in accordance with circumstances. Thus, when deriving formula (2), we assumed conditionally that the possibility of seeing noctilucent clouds is identically probable when the sun is 6 to 18 degrees below the horizon during the entire interval. In fact, as the sun sinks below the horizon, the possibility of discerning the brightest formation increases, then the less bright formations. At a certain value of D (the angle at which the sun is sunk below the horizon), the ratio between the brightness of the clouds and the background of the sky becomes optimal, after which the conditions of visibility deteriorate again. Therefore, in a more rigorous solution of the problem it will be necessary to bear in mind the change in the probability $P_D$ of discovering noctilucent clouds as the sun sinks to a deeper angle below the horizon D.

The same thing may be said of the effect of cloudiness. Discovery of noctilucent clouds is possible not only when the sky is completely clear, but also when a segment of the sky is partially covered with clouds of different levels, even though it is less probable in this case. Therefore, it is necessary to introduce still another parameter $P_O$ to express the probability of seeing noctilucent clouds during this state of the sky. In accordance with our operative procedure for recording observations, the latter is expressed in letter symbols corresponding to a five-number scale (A - completely clear, $P_O = 1$; D - completely overcast, $P_O = 0$; the problem of values of $P_O$ for intermediate degrees should be the subject of special study).

One may proceed in this manner to solve the problem of obtaining the frequency of appearances of noctilucent clouds to the second approximation. For each period of observation we shall have a symbolic description of the state of the sky and the angle the sun is sunk below the horizon D. This permits obtaining the product $P_D P_O$ for each period. Then, we count the number of periods N during which noctilucent clouds were noticed, for ten-day periods and for latitudinal zones. Assuming that Q = 1, we may accept the frequency h as being for this approximation:

$$h = q \frac{N}{\Sigma P_D P_O}, \qquad (3)$$

where q - is an arbitrary constant, and $\Sigma P_D P_O$ is the sum of the products for all periods during which observations were made in the given latitude during the given ten-day period, regardless of whether or not noctilucent clouds were visible.

The method of calculation set forth here is still only a theoretical procedure inasmuch as the determination of the probabilities $P_D$ and $P_O$ requires special research. Moreover, it is suggested here that the phenomenon of noctilucent clouds does not depend upon synoptical conditions in the troposphere, for in the opposite case, the appearance of noctilucent and tropospheric clouds can turn out to be linked by a common causality.

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# ON THE CONTROL OF THE PERMANENCY OF AIRGLOW TRANSPARENCY

By L. M. Fishkova

When making electrophotometric observations of the daily variations of the airglow, it is necessary to know the changes in the transparency of the atmosphere during the night. The use of seasonal transparency coefficients or mean coefficients for a night are wholly inadequate for this purpose. According to the program of electrophotometrical observations of the airglow contained in the general program of the MGG, it was decided to control the transparency during the night by measuring the brightness of Polaris (Alpha Ursae Minoris, stellar magnitude of $2^m.12$, spectral class F8), since it can be recorded with the same photometer that is used to observe the airglow, due to the constancy of the zenith angle and its comparatively great brightness. If the extra-atmospheric brightness of Polaris is determined provisionally, expressed in units of deviation of the instrument placed at the output of the electrophotometer, then every reading on Polaris will indicate directly the transparency of the atmosphere at a given instant. One must bear in mind, however, that Polaris is a variable star of the Cepheid type. Its brightness in the visible region of the spectrum changes with an amplitude of $0^m.14$ stellar magnitudes in a period of 3.97 days [1]. Therefore it is not sufficient to know merely the mean extra-atmospheric value of its brightness, but it is essential to construct a curve of its extra-atmospheric brightness in the color system in which the observations are made.

The extra-atmospheric curve of variability of Polaris, which was obtained in the Abastumani Observatory and used in the control of atmospheric transparency, is presented here. The brightness of Polaris was measured with an electrophotometer equipped with an 8-centimeter objective and a photomultiplier with a bismuth-silver-cesium photocathode. For several clear nights, simultaneous measurements were made without a light filter of the brightness of Polaris, of Epsilon Ursae Minoris (stellar magnitude $4^m.40$, spectral class G5), taken as a star of comparison, and the brightness of Alpha Aurigae (Capella) for different Z. Measurements of alpha Aurigae by Burger's method provided a value of the transparency coefficient which was used to determine the extra-atmospheric brightness of Epsilon Ursae Minoris, which was used in turn to provide (by comparison) extra-atmospheric values of the brightness of Polaris for its different phases.

The extra-atmospheric curve of variability of Polaris constructed on the basis of these data is presented in the figure; readings of the instrument placed at the output of the electrophotometer are represented by the ordinates of the graph. The brightness of both Polaris and Epsilon Ursae Minoris were measured without light filters. A photomultiplier with a bismuth-silver-cesium photocathode was used in the electrophotometer, therefore the effective length of the wave for which the curve was obtained would be approximately $\lambda$ 5200 Angstrom units. The curve shown in the figure was then used for control of transparency, both from night to night as well as during the nights of observations. For this purpose, the brightness of Polaris n was measured every hour and, in accordance with it extra-atmospheric values $n_0$ for a given phase, the transparency coefficient was calculated

$$P = \sqrt[mz]{n/n_0}$$

. To make the conversion from $P\lambda$ for $\lambda$ 5200 Angstrom units to $P\lambda$ for $\lambda$ 5577, 5893 Angstrom units, et cetera, data on the spectral transparency obtained at the Mount Wilson Observatory were used. There will be no need for the latter if the extra-atmospheric curve for Polaris is determined for all those light filters employed in observations of the airglow.

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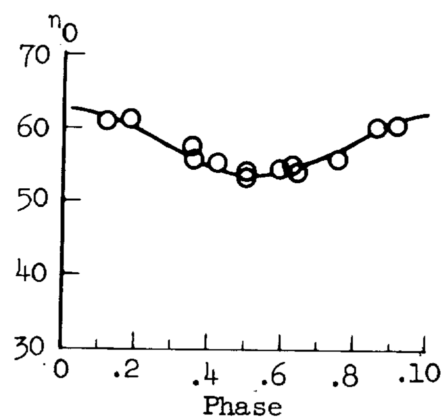


Figure 1.- The extra-atmospheric curve of the variability of Polaris.

# A STUDY OF MOVEMENTS (OF WINDS) IN THE F2 LAYER BY THE PHASE METHOD, TAKING INTO ACCOUNT THE ANISOTROPY OF THE FORM AND THE VARIABILITY OF HETEROGENEITIES

By V. D. Gusev and S. F. Mirkotan

In accordance with the program of the MGG [Mezhdunarodnyy geofizicheskiy god — International Geophysical Year], an extensive network of stations is making studies of the parameters of the heterogeneities of the ionosphere and their movements. The presence of these heterogeneities has a material effect on the quality and stability of radio communications. Study of ionospheric heterogeneities is facilitating the study of the dynamics of the ionospheric plasma.

The standard equipment and methods for such studies are set forth in [1]. The amplitude fading of signals reflected from the ionosphere is recorded at three points located on the vertices of a triangle. Rapid amplitude fading corresponding to the presence of small-scale heterogeneities (in tens or hundreds of meters) in the ionosphere are recorded. Determining the lags in fading at one point in respect to others permits one to calculate the apparent velocity V' of the movement of heterogeneities along the corresponding sides of the measuring triangle. This includes the so-called method of similarity recommended as the principal method for the MGG [1]. The complete apparent velocity V' coincides with the true velocity of drift $V_d$, if the ionospheric heterogeneities are isotropic in form and are not subjected to chaotic variability. Anisotropy of form and the presence of chaotic variability in the heterogeneities in addition to drift leads to a situation in which information on the magnitude and direction of drift obtained from the method of similarity will contain errors. The amount of error will depend on the degree of anisotropy and the contribution of the chaotic changes in comparison with regular drift movements. However, information on the anisotropy and variability of heterogeneities are also of independent interest in the study of the dynamics of the ionosphere.

The ionospheric group of the Chair of Propagation of Radio Waves of the Physics Department of Moscow has been carrying on research since 1956 on movements in the ionosphere, employing its own original phase method, which differs from the generally established one [2]. This research will permit the acquisition of important information in regard to large heterogeneities (in tens or hundreds of kilometers). The observations were processed with the aid of a complete correlation analysis which permitted evaluation of the degree of anisotropy of the form of the heterogeneities and their variability, that is, to take into account factors which limited the justification for employing the method of similar fading.

Since large heterogeneities are the subject of the research, this required the location of transmitting-receiving points on the vertices of a triangle with sides of 30-60 kilometers. Fluctuations of phase of signals reflected from the ionosphere were recorded at each of the three points. The synchronization of observations at these points (the transmission of time markers and coded control signals) was provided for with the aid of a special communications system (radio relay communications). Continuous observations lasting from 24 to 100 hours are made there on global days and on days recommended for observations. Recordings of observations of four hours' duration are selected for direct processing, that is, for acquisition of information on ionospheric heterogeneities. This interval was chosen on the basis of considerations of proper statistical processing in order that it might include an adequate number of cycles of phase fluctuations connected with the movements of large heterogeneities [3]. Recordings of phase [fluctuations] are tabulated. Three mutually correlative functions and one self-correlative function for recording the fluctuations of phase are determined with the aid of an electronic computer. The essential point of correlation analysis in the study of a heterogeneity of the ionosphere consists in the fact that if one knows the functions mentioned above, it is possible to determine, in particular [4] the true velocity and direction of the velocity of drift $V_d$, the parameters of the "characteristic ellipse" which represents the mean form of the heterogeneity, and their orientation in space. This ellipse is described by the relationship of the axes and the orientations. It is also possible to calculate the velocity $V_c$ which describes the spreading, the variability, and certain other parameters.

Research done in 1957 - 1958 resulted in establishing the fact of the existence of anisotropy of the form of large heterogeneities. Figure 1 shows histograms of the distribution of relationship of the axes of anisotropy e for different times of the day: night (00 - 06 hours), morning (06 - 12 hours), day (12 - 18 hours), evenings (18 - 24 hours), and histograms of e for a day. The time is local — Moscow time. These data and those presented below were obtained as a result of correlation processing of more than 100 observations (400 hours of observations) from January 1957 through May 1958. The values of e lie in an interval of 1 - 7 with values on the order of 2 most frequently encountered, and depend but little on the time of day. It is true that larger values of e are encountered at night than during the day. In addition, the predominating orientation of the major axis of anisotropy was discovered to be along the magnetic meridian.

Figure 2 shows the average form of the spatial dimensions of large heterogeneities and the average orientation of the axes of anisotropy depending upon the time of day and for a day. NS - is the direction of the geographical meridian, and MM - is that of the magnetic. $_{MIN}$ and $_{MAX}$ -

are the spatial dimensions of the heterogeneities along the minor and major axes, respectively. It is seen from Figure 2 that the dimensions of the heterogeneities increase from day to night. The degree of anisotropy increases toward night.

Values of the velocities V and $V_d$ were calculated for the same period. Figure 3 presents histograms of the ratio $V_c/V_d$ which characterizes the relationship between regular movements and chaotic variability in the ionosphere. $V_c$ exceeds $V_d$ frequently, especially in the daytime. The average value of $V_c/V_d = 1.5$. Thus, in addition to the regular wind $V_d$, there is a chaotic variability of significant size in the ionosphere which is apparently caused by turbulent movements and processes of a diffusion character. The presence of $V_c$ should lead to a situation in which the modulus of drift velocity determined with the method of similarity will be larger than the true value, for $V'V_d \quad V_d^2 - V_c^2$, but $V'$ $V_d$ only when $V_c \quad 0$ [4].

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The results which we have presented refer directly to large ionospheric heterogeneities. In the meantime, however, preliminary data indicate the presence of anisotropy of form for small-scale heterogeneities, too [5]. The conclusion concerning the presence of velocities of chaotic changes $V_c$ in the ionosphere which are material as compared with the regular drift velocities, agrees with the information presented in the work [6] done for small-scale heterogeneities. This correspondence of the characteristics of large and small heterogeneities apparently indicates the possibility of the common nature of the processes that control the formation and movements of all ionospheric heterogeneities.

The results obtained in this work indicate the necessity for verifying the information on drifts in the ionosphere obtained by the method of similarity with the aid of complete correlation analysis. In particular, without such checking of data on the existence of a predominantly east-to-west direction of drift obtained by the stations in Moscow, Tomsk, Ashkhabad, and Khar'kov [7] may to a large extent be a consequence of anisotropy of form of the heterogeneities and the predominant orientation of the major axis of anisotropy along a north-south direction.

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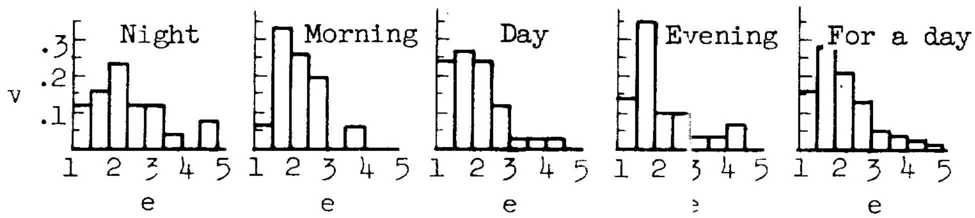


Figure 1.- Histograms of the ratio of the axes of anisotropy e of large heterogeneities for different times of the day and for a day. v is the relative frequency (F2-layer, January 1957 through May 1958).

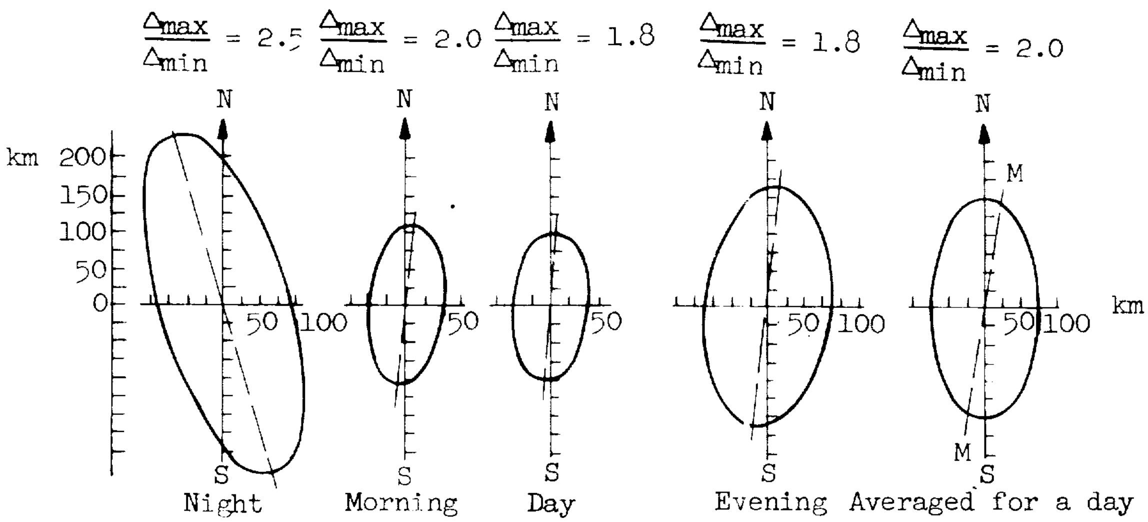


Figure 2.- The dependence of the mean form of large heterogeneities and their orientation on the time of day (F2-layer, January 1957 through May 1958).

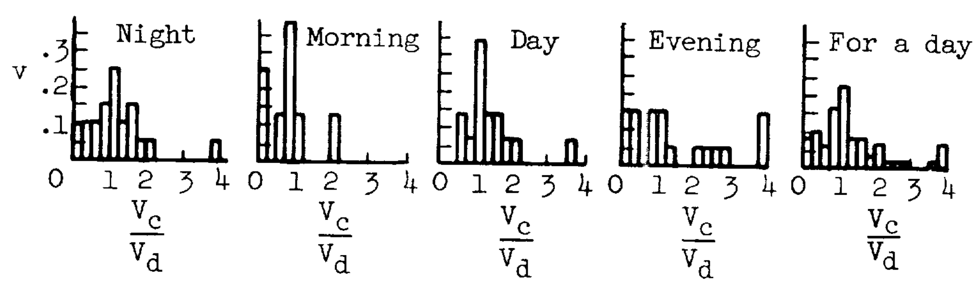


Figure 3.- Histograms of the $V_c/V_d$ ratio for large heterogeneities for the period from January 1957 through May 1958 (F2-layer).

# FOREIGN METHODS OF OBSERVATIONS. GEOPHYSICAL RESEARCH CARRIED OUT WITH ROCKETS AND ARTIFICIAL EARTH SATELLITES IN THE UNITED STATES IN ACCORDANCE WITH THE PROGRAM OF THE INTERNATIONAL GEOPHYSICAL YEAR

By M. G. Kroshkin

In the beginning of 1958, the Soviet Committee of the MGG [Mezhdunarodnyy geofizicheskiy god -- International Geophysical Year] received material in regard to the American program of work on rocket sounding of the atmosphere, on plans of research with artificial earth satellites, and some information on the progress made on their fulfillment. Subsequently, this material was supplemented by other items which were presented by the American Committee for the IGY to World Data Center B (Moscow) and reported at the symposium on research on the upper atmosphere with rockets and artificial earth satellites which was convened at the time of the Fifth Assembly of the SK [Meaning of this abbreviation is not clear; it could mean either Special Committee or Soviet Committee] of the IGY in Moscow (July - August 1958).

The program provided for rocket sounding of the atmosphere by American forces at Fort Churchill (Canada), in the North Atlantic, in Baffin Bay, at White Sands (New Mexico), at Holloman (New Mexico), on San Nicholas (California), at Point Mugu (California), on the Danger Islands (Northern Cook Islands), on Guam Island (Mariana Islands), and from shipboard in the Antarctic, the Pacific Ocean, and the Arctic.

Prior to the beginning of the IGY, it was suggested that rocket soundings be made on Christmas Island in the Pacific Ocean. Later, in connection with the carrying out of nuclear tests in this area, this part of the program was dropped.

A portion of the materials which arrived in the beginning of 1958 on projects developed in the United States for artificial earth satellites described telemetering devices in such detail as an amateur [observer] or an organization that wished to conduct observations of the satellites would require.

A large portion of the materials received by the Committee was on the subject of the Vanguard Satellite Project, which was not launched either in 1957 nor in 1958. The object that is usually called the Vanguard Satellite (the second American satellite) is not a satellite in the scientific sense of the word inasmuch as no experiments whatever were carried out in it on the study of the upper atmosphere in accordance with the Vanguard program. It is not a satellite, but a test sphere.

The data on launched satellites and the results of research accomplished with their aid were received after launching and were based on official communiques, scientific publications, and information published in the American press.

In the process of fulfilling the program of geophysical research with rockets and satellites during the first 12 months of the International Geophysical Year, the United States made 116 rocket launchings and four successful launchings of artificial earth satellites (the fifth launching was made on 19 December, not in accordance with the IGY program). It should be noted that a large number of the attempts to launch satellites and also the four attempts to send a rocket to the Moon in 1958 turned out to be unsuccessful.

A characteristic feature of the satellites launched in the United States is their small size. This limits the scientific use of the satellites and is explained by the inadequate technical possibilities of the means for launching at the disposal of the United States up to the end of 1958. As a consequence of this, a large portion of the results of geophysical research obtained by July 1958 and reported by American scientists at the symposium of the Fifth Assembly of the SK of the IGY refer to results obtained with rocket research.

The United States obtained important data from observations of Soviet artificial earth satellites.

I. ROCKET RESEARCH OF THE UPPER LAYERS OF THE ATMOSPHERE

a) Research program

The American program of rocket research calls for measuring the atmospheric pressure, temperature, density, and winds at different altitudes (up to 90 - 120 kilometers). Photographing the horizon at great altitudes, determining the chemical composition of the upper layers of the atmosphere, including the water vapor and ozone contents; studying the ionic composition (measuring the density of charge in the ionosphere), the ultraviolet and x-ray spectra of the Sun, in particular, $L_\alpha$ [Translator's note: Apparently Lyman alpha] radiation, the luminescence of the air, cosmic rays, and the magnetic field of the earth are also ascertained.

Fulfillment of the program called for the participation of the following organizations.

1. The Scientific Research Center of the Air Force of the United States in Cambridge (Massachusetts), Department of Geophysical Research (AFCRC).

2. The Artillery Headquarters of the United States Army.

3. The Ballistics Laboratory, with proving grounds in Aberdeen (Maryland) (BRL).

4. The Naval Research Laboratory of the United States (NRL).

5. The Artillery Headquarters of the United States Navy, Naval Air Missiles Research Center at Point Mugu (California) (NAMTC).

6. The College of Agriculture and Mechanical Arts of New Mexico.

7. The United States Radio Communications Laboratory (SEL) or (USASRDL).

8. Iowa State University (SUI).

9. Michigan University.

10. Ships of the United States Navy.

11. White Sands Proving Grounds.

12. The Holloman Air Force Base.

The participation of certain Canadian organizations in also provided for in the rocket research:

1) Bases at Fort Churchill,
2) the Canadian Department of Transport, and
3) Department of Research of the Canadian Ministry of Defense.

The preliminary American program on rocket sounding of the atmosphere was published in the United States was received by the Soviet Committee for Conducting the IGY a long time ago. However, as the latest data on the progress of rocket sounding during the first twelve months of the IGY are not in complete agreement with this program, there is no need for publishing it in this bulletin. Instead of this, the program of rocket research to be completed during the second half (Table 1) of 1958, also data on the progress of rocket sounding in the United States during the first twelve months of the IGY, through July 1958 (Table 2) will be presented here.

TABLE 1

PROGRAM OF ROCKET SOUNDING FOR THE SECOND HALF OF 1958

| Launching Site | Type of Rocket | Approximate Date of Launching | Number of Launchings |
|---|---|---|---|
| Fort Churchill | Aerobee, Nike-Cajun, SPAEROBI | 8 July - 15 December | 41 |
| White Sands, Holloman | Aerobee, Nike-Cajun | 1 July - October | 8 |
| Point Mugu | Nike-Asp | 1 - 31 July | 5 |
| Danger Island | Nike-Asp | 1 - 12 October | 8 |
| Guam Island | Nike-Asp | November - December | 8 |
| | | Total | 70 |

[Translator's note: Words in all caps are transliterated, one appears to be Spaerobee].

TABLE 2

ROCKET LAUNCHINGS CARRIED OUT IN THE FIRST 12 MONTHS OF THE IGY

| Launching Region | Type of Rocket | Number of Launchings |
|---|---|---|
| Fort Churchill | Aerobee | 21 |
| | Nike-Cajun | 20 |
| White Sands, Holloman | Aerobee | 3 |
| | Nike-Cajun | 2 |
| | Nike-Asp | 1 |
| San Nicholas Island | Nike-Deacon | 14 |
| | Nike-Asp | 1 |
| Arctic (launching from ships) | Rockoon | 18 |
| Pacific Ocean and Antarctica (launching from ships) | Rockoon | 36 |
| | Total | 116 |

The Soviet Committee does not as yet have data on the American program on rocket sounding for 1959.

b) Rockets used by the United States for studying the upper layers of the atmosphere. Methods and organization of the studies.

Experiments on rocket sounding have been carried on in the United States since 1946. Captured German V-2 rockets were used in those experiments. Later, special meteorological rockets were developed which were launched directly from the earth and from balloons. Launchings from the earth are being made at present in experiments which must be carried out at a definite instant, for example, when certain phenomena are occurring on the Sun.

The use of liquid fuel rockets in experiments in Arctic regions was recognized to be difficult, therefore, the two-stage powder rocket Nike-Deacon, later modified and renamed the Nike-Cajun by combining it with the Cajun rocket was recommended for Arctic research along with the Aerobee rocket (Aerobee-Hi).

The materials contained a brief description of the equipment of one of the rocket sounding points -- Fort Churchill.

Its general equipment consists of a tower for launching Aerobee rockets which permits turning in any direction to compensate for wind drift, facilities for launching Nike-Cajun rockets, space for preparing launchings, telemetering facilities, a blockhouse, space for generators, helium storage, and connecting tunnels.

The rocket range has a system of five stations for Doppler radio tracking of rockets, the so-called DOVAP, and several kine-theodolites installed by the Ballistics Research Laboratory (BRL). There are two radars protected by shelters, a command transmitter, frequency-measuring apparatus, a system for time metering, aerological apparatus for checking the wind with the aid of pilot balloons, and a general communications system.

c) Test launchings

Prior to the beginning of the International Geophysical Year test launchings were made with the purpose of checking apparatus and methods. These launchings showed, in particular, that the range at Fort Churchill was wholly suitable for making soundings of the atmosphere. A total of six rockets was launched. The results of one launching were processed and provided a distribution of temperatures which coincided with the data from radio sounding (up to altitudes of 30 kilometers). These data show the presence of a temperature maximum at a greater altitude than at White Sands. However, the value of the temperature is the same -- 280 degree Kelvin. The winds are westerly, but stronger than those measured previously -- up to 150 meters per second. The method for measuring the temperature and winds was accurate, as noted before.

A successful launching was made on Wallops Island (Virginia) on 5 July 1956 in which the density of the air was measured.

Ten Rockoon rockets equipped with apparatus for studying ultraviolet and x-ray radiation at the time of solar flares were launched by the Navy from a ship off Southern California. Since it was impossible to obtain rapid launching at the instant of a solar flare in the case of rockets which were started with balloons, those rockets were replaced by Nike-DIKON rockets in this portion of the program.

Two Nike-Cajun rockets were launched at the White Sands Proving F
Grounds in New Mexico on 7 - 9 August 1956. One of them was equipped 5
with apparatus for measuring pressure, temperature, and density; the 0
second with apparatus for studying the density of charge of the ionosphere. Both launchings were successful.

Five Nike-Cajun rockets were launched from a ship in the Atlantic Ocean on a voyage from the United States to Northern Greenland. More detailed data on all these launchings are given below.

d) Fulfillment of the program of rocket research [See Note]. In accordance with the survey paper by H. Newell read at the Fifth Assembly of the SK of the IGY, (Tables 3-7).

The following were determined in the process of these launchings:

1) The density of the atmosphere, its pressure, and temperature;

2) Winds at great altitudes;

3) Cloudiness and density of the atmosphere (with high-altitude photography);

4) The chemical composition of the atmosphere (upper), including ozone and water vapor;

5) Changes in ionic density;

6) Solar ultraviolet and x-ray radiation, including observations made at the time of solar prominences;

7) The luminescence of the atmosphere;

8) The aurora borealis;

9) Corpuscular radiation at the time of the aurora borealis;

10) Variations in cosmic rays;

11) The magnetic field of the earth;

12) Rocket astronomy.

TABLE 3

THE LAUNCHING OF ROCKETS FROM SAN NICHOLAS ISLAND
($34^\circ$ 7' North Latitude, $119^\circ$ West Longitude)

| No IGY | Launching Date | Content of Experiments | Quality of Experiments | Characteristics of the Rocket | Maximum Altitude, km |
|---|---|---|---|---|---|
| | | 1957 | | | |
| HH 7.37F | 1 July | Radiation in the L$\alpha$ region, x-rays and soft gamma radiation | Limited data | Unsatisfactory | 93 |
| NN 7.38F | 3 July | | Satisfactory | Successful | 113 |
| NN 7.39F | 15 July | | No data | Unsatisfactory | 21 |
| NN 7.40F | 23 July | | Satisfactory | Successful | 129 |
| NN 7.41F | 5 August | | No data | Unsatisfactory | 14 |
| NN 7.42F | 20 August | | Satisfactory | Successful | 97 |
| NN 7.43F | 27 August | | No data | Unsatisfactory | 16 |
| NN 7.44F | 28 August | | Limited data | Successful | 96 |
| NN 7.45F | 29 August | | Satisfactory | Successful | 113 |
| NN 7.46F | 12 September | | No data | Unsatisfactory | Not known |
| NN 7.47F | 15 September | | No data | Successful | Not known |
| NN 7.48F | 18 September | | No data | Unsatisfactory | 21 |
| NN 7.49F | 18 September | | Limited data | Unsatisfactory | 77 |
| NN 8.50F | 26 September | | No data | Unsatisfactory | 16 |
| NN 8.51F | 10 December | | Limited data | Unsatisfactory | 169 |

Total 15 launchings

TABLE 4

ROCKET LAUNCHINGS AT FORT CHURCHILL
($58^\circ$ 46' North Latitude, $94^\circ$ 10' West Longitude)

Letter Symbols

D - pressure
T - temperature
P - density
V - winds
MP - magnetic field
KPPS - corpuscular streams in the aurora Borealis
KhIS - chemical and ionic composition
NG - observations of the horizon
KI - intensity of cosmic ray radiation
PZ - density of charge in the ionosphere

| IGY[1] No | Date of Launching | Content of Experiment | Quality of Experiment | Characteristics of Rocket Launching | Maximum Altitude, Kilometers |
|---|---|---|---|---|---|
| [1] | [2] | [3] | [4] | [5] | [6] |
| | | Prior to the IGY, 1956 | | | |
| AM 6.34 | 20 October | DTP | Satisfactory | Successful | 112 |
| AM 2.21 | 23 October | DTP | Satisfactory | Successful | 145 |
| NN 3.02 | 5 November | KPPS, MP | Unsatisfactory | Unsuccessful | Unsatisfactory |
| SM 1.01 | 12 November | TB | Satisfactory | Below estimate | 68 |
| NN 3.07 | 15 November | PZ | Satisfactory | Below estimate | 129 |
| NN 3.12 | 17 November | DP | Satisfactory | Successful | 209 |
| NN 3.17 | 20 November | KhIS | Satisfactory | Successful | 254 |
| | | During the IGY, 1957 | | | |
| NN 3.08F | 4 July | PZ | Satisfactory | Successful | 257 |
| NN 3.09F | 4 July | PZ | Limited data | Unsatisfactory | 16 |
| SM 1.02 | 22 July | TV | Satisfactory | Successful | 92 |
| SM 1.03 | 23 July | TV | Satisfactory | Successful | 87 |
| NN 3.13 | 29 July | DTP | Satisfactory | Successful | 211 |
| AM 6.32 | 30 July | DTP | Unsatisfactory | Unsatisfactory | 23 |
| SM 1.04 | 12 August | T | Satisfactory | Below estimate | 74 |
| SM 1.05 | 19 August | TV | Satisfactory | Successful | 93 |
| RPX 6.XI | 23 August | Test | Satisfactory | Successful | 113 |
| SS 6.38 | 24 August | TV | Unsatisfactory | Unsatisfactory | Not known |
| SM 2.06 | 25 August | TV | Satisfactory | Successful | 130 |
| II 6.22F | 27 August | KPPS, KI | No data | Unsatisfactory | Not known |
| II 6.23F | 30 August | KPPS, KI | Limited data | Successful | 113 |
| AM 4.01 | 1 September | DTP | Satisfactory | Satisfactory | 159 |
| SS 6.39 | 10 December | TV | Unsatisfactory | Unsatisfactory | Not known |
| SM 1.07 | 11 December | TV | Satisfactory | Successful | 85 |
| SM 1.08 | 14 December | TV | Satisfactory | Successful | 80 |
| AM 6.34 | 14 December | DTP | Unsatisfactory | Unsatisfactory | Not known |
| | | 1958 | | | |
| AM 6.02 | 25 January | DTP | Satisfactory | Successful | 161 |
| NN 3.03F | 25 January | KPPS, MP | Satisfactory | Successful | 180 |
| SM 1.09 | 27 January | TV | Satisfactory | Successful | 98 |
| SM 2.10 | 27 January | TV | Satisfactory | Successful | 151 |
| AM 6.36 | 27 January | DTP | Satisfactory | Successful | 129 |
| AM 6.03 | 29 January | DTP | Satisfactory | Successful | 161 |
| NN 3.10F | 3 February | PZ | Satisfactory | Below estimate | 138 |
| NN 3.11F | 4 February | PZ | Satisfactory | Successful | 235 |
| II 6.24F | 13 February | KPPS, MP | Satisfactory | Below estimate | 129 |

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| [1] | [2] | [3] | [4] | [5] | [6] |
|---|---|---|---|---|---|
| II 6.25F | 16 February | KPPS, MP | Satisfactory | Below estimate | 121 |
| NN 3.18F | 21 February | KhIS | Satisfactory | Successful | 225 |
| II 6.26F | 21 February | KPPS, MP | Satisfactory | Below estimate | 129 |
| NN 3.14F | 24 February | DTP | Satisfactory | Successful | 206 |
| AM 6.37 | 24 February | DTP | Satisfactory | Successful | 143 |
| II 6.27F | 24 February | KPPS, MP | Satisfactory | Below estimate | 129 |
| RPX 6.X2 | 26 February | Test | Satisfactory | Unsatisfactory | Not known |
| AM 6.04 | 4 March | DTP | Unsatisfactory | Not known | Not known |
| AM 6.05 | 4 March | DTP | Satisfactory | Successful | 169 |
| NN 3.04F | 15 March | KPPS, MP | Satisfactory | Below estimate | 126 |
| NN 3.05F | 22 March | KPPS, MP | Satisfactory | Successful | 167 |
| NN 3.19F | 23 March | KhIS | Satisfactory | Successful | 206 |
| OB 6.08 | 24 March | NG | Satisfactory | Successful | 119 |
| AM 6.38 | 24 March | DTP | Satisfactory | Successful | 137 |
| | | | Total | 41 launchings | |

[1]Symbols accepted in the documentation of the American Committee of the IGY are given in this and the following tables.



TABLE 5

RESULTS OF ROCKET RESEARCH AT WHITE SANDS AND HOLLOMAN

Letter Symbols

UFS - Ultraviolet radiation from the Sun
MP - magnetic field
MM - micrometeors
SF - photon counter
SV - luminescence of the air
[Note: Literal, possibly air glow]
PZ - density of charge
PV - water vapor

| IGY No | Date of Launching | Place of Launching | Content of Experiment | Quality of Experiment | Characteristics of Rocket Launching | Maximum Altitude, Kilometers |
|---|---|---|---|---|---|---|
| AS 4.24 | 6 August | Holloman | UFS | Satisfactory | Successful | 145 |
| OB 6.02 | 10 December | White Sands | PZ, MP | Excellent | Extra successful | 145 |
| II 8.35 | 8 January | White Sands | MM, SF | Unsatisfactory | Below estimate | 145 |
| 3.22 | 5 May | White Sands | UFS | Partial data | Successful | 214 |
| AA 4.25 | 18 March | Holloman | UFS | Satisfactory | Successful | 107 |
| | | | | Total | 6 launchings | |

TABLE 6

ROCKET LAUNCHINGS IN THE ARCTIC (FROM SHIP) IN 1957

Letter Symbols

KI - intensity of cosmic ray radiation
IPS - aurora borealis
MP - magnetic field

| IGY No | Date of Launching | Place of Launching | Content of Experiment | Quality of Experiment | Characteristics of Rocket Launching | Maximum Altitude, Kilometers |
|---|---|---|---|---|---|---|
| [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| II 5.01 | 5 August | 55°00'N.Lat 54°00'W.Long | KI, IPS | No data | Not known | Not known |
| II 5.02 | 5 August | 56°37'N.Lat 54°25'W.Long | MP | Only balloon flight | Not known | Not known |
| II 5.03 | 6 August | 62°16'N.Lat 56°17'W.Long | KI, IPS | Satisfactory | Successful | 116 |
| II 5.04 | 6 August | 63°56'N.Lat 56°09'W.Long | MP | Satisfactory | Successful | 117 |
| II 5.05 | 7 August | 67°20'N.Lat 57°03'W.Long | KI, IPS | Only balloon flight | Unsatisfactory | Unsatisfactory |
| II 5.06 | 7 August | 72°55'N.Lat 58°31'W.Long | MP | No data | Unsatisfactory | Unsatisfactory |
| II 5.07 | 8 August | 75°12'N.Lat 63°19'W.Long | KI, IPS | Unsatisfactory | Successful | 132 |
| II 5.08 | 10 August | 74°18'N.Lat 63°34'W.Long | KI, IPS | Unsatisfactory | Successful | 117 |
| II 5.09 | 10 August | 72°04'N.Lat 58°20'W.Long | KI, IPS | Unsatisfactory | Below estimate | 77 |
| II 5.10 | 11 August | 70°40'N.Lat 57°00'W.Long | KI, IPS | Only balloon flight | Unsatisfactory | Unsatisfactory |
| II 5.11 | 11 August | 66°56'N.Lat 54°56'W.Long | KI, IPS | Unsatisfactory | Successful | 122 |

| [1] | [2] | [3] | [4] | [5] | [6] | [7] |
|---|---|---|---|---|---|---|
| II 5.12 | 12 August | 64°14'N.Lat 53°57'W.Long | KI,IPS | Only balloon flight | Unsatis-factory | Unsatisfactory |
| II 5.13 | 12 August | 63°03'N.Lat 53°43'W.Long | MP | Same | Not known | Not known |
| II 5.14 | 13 August | 60°35'N.Lat 49°16'W.Long | KI,IPS | Limited data, during bal-loon flight | Not known | Not known |
| II 5.15 | 14 August | 59°18'N.Lat 47°48'W.Long | KI,IPS | Only balloon flight | Not known | Not known |
| II 5.16 | 14 August | 57°44'N.Lat 48°09'W.Long | MP | Satisfactory | Successful | 97 |
| II 5.17 | 14 August | 56°13'N.Lat 48°40'W.Long | KI,IPS | Satisfactory | Successful | 89 |
| II 5.18 | 14 August | 55°40'N.Lat 48°56'W.Long | KI,IPS | Satisfactory | Successful | 97 |
| | | | | Total | 18 launchings | |

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TABLE 7

ROCKET LAUNCHINGS IN EQUATORIAL AND ANTARCTIC REGIONS (PACIFIC OCEAN) IN 1957

Letter Symbols

KI - intensity of cosmic ray radiation
IPS - aurora Borealis
MP - magnetic field

| IGY No [1] | Date of Launching [2] | Place of Launching [3] | Content of Experiment [4] |
|---|---|---|---|
| II 5.50F | 26 September | 30°37' N. Latitude 74°09' W. Longitude | Test |
| II 5.51F | 27 September | 25°20' N. Latitude 74°24' W. Longitude | KI |

| [1] | [2] | [3] | [4] |
|---|---|---|---|
| II 5.52F | 4 October | 05°28' N. Latitude<br>89°29' W. Longitude | KI |
| II 5.53F | 13 October | 02°10' N. Latitude<br>143°08' W. Longitude | KI |
| II 5.54F | 14 October | 02°16' N. Latitude<br>150°23' W. Longitude | MP |
| II 5.55F | 16 October | 07°07' N. Latitude<br>156°38' W. Longitude | MP |
| II 5.56F | 17 October | 06°28' N. Latitude<br>156°55' W. Longitude | MP |
| II 5.57F | 17 October | 06°11' N. Latitude<br>157°01' W. Longitude | MP |
| II 5.58F | 17 October | 03°56' N. Latitude<br>158°07' W. Longitude | MP |
| II 5.59F | 17 October | 03°23' N. Latitude<br>158°41' W. Longitude | MP |
| II 5.60F | 18 October | 01°52' N. Latitude<br>159°55' W. Longitude | KI |
| II 5.61F | 18 October | 00°48' N. Latitude<br>160°32' W. Longitude | MP |
| II 5.62F | 18 October | 00°02' N. Latitude<br>160°52 W. Longitude | MP |
| II 5.63F | 19 October | 02°05' S. Latitude<br>161°05' W. Longitude | MP |
| II 5.64F | 20 October | 02°31' S. Latitude<br>161°25' W. Longitude | MP |
| II 5.65F | 20 October | 02°50' S. Latitude<br>161°28' W. Longitude | KI |
| II 5.66F | 20 October | 06°50' S. Latitude<br>162°10' W. Longitude | KI |

| [1] | [2] | [3] | [4] |
|---|---|---|---|
| II 5.67F | 22 October | 17°42' S. Latitude<br>163°24'W. Longitude | KI |
| II 5.68F | 26 October | 39°04' S. Latitude<br>165°59' W. Longitude | KI |
| II 5.69F | 27 October | 40°27' S. Latitude<br>166°11' W. Longitude | KI |
| II 5.70F | 29 October | 50°43' S. Latitude<br>169°39' W. Longitude | KI, IPS |
| II 5.71F | 30 October | 60°05' S. Latitude<br>176°06' W. Longitude | KI, IPS |
| II 5.72F | 31 October | 60°44' S. Latitude<br>176°38' W. Longitude | KI, IPS |
| II 5.73F | 31 October | 65°03' S. Latitude<br>177°51' W. Longitude | MP |
| II 5.74F | 1 November | 65°38' S. Latitude<br>177°38' W. Longitude | MP |
| II 5.75F | 3 November | 70°14' S. Latitude<br>175°42' E. Longitude | MP |
| II 5.76F | 3 November | 70°48' S. Latitude<br>175°50' E. Longitude | KI, IPS |
| II 5.77F | 4 November | 71°10' S. Latitude<br>176°08' E. Longitude | MP |
| II 5.78F | 4 November | 71°28' S. Latitude<br>176°45' E. Longitude | MP |
| II 5.79F | 4 November | 71°58' S. Latitude<br>176°40' E. Longitude | KI, IPS |
| II 5.80F | 4 November | 70°51' S. Latitude<br>173°33' E. Longitude | MP |
| II 5.81F | 5 November | 69°32' S. Latitude<br>173°38' E. Longitude | KI, IPS |

| [1] | [2] | [3] | [4] |
|---|---|---|---|
| II 5.82F | 5 November | $66^{\circ}35'$ S. Latitude<br>$174^{\circ}37'$ E. Longitude | MP |
| II 5.83F | 5 November | $66^{\circ}09'$ S. Latitude<br>$174^{\circ}41'$ E. Longitude | MP |
| II 5.84F | 8 November | $48^{\circ}18'$ S. Latitude<br>$173^{\circ}41'$ E. Longitude | KI, IPS |
| II 5.85F | 8 November | $48^{\circ}01'$ S. Latitude<br>$173^{\circ}50'$ E. Longitude | KI, IPS |
| | | Total | 36 launchings |



e) A brief summary of the results obtained

In respect to density, pressure, and temperature:

1. Over Fort Churchill, at an altitude of 200 kilometers, during the day in the summer season, the density of the atmosphere was $6.6 \times 10^{-7}$ grams per cubic centimeter, or double the density of the atmosphere in the winter. ([See Note] LA GOU (La Gow), KhOROVITs (Horowits), and EYNSVORT (Ainsworth), NRL).

2. The density of the atmosphere over Fort Churchill at an altitude of 200 kilometers during the day in the summer season was five times the density over White Sands (equal to $1.4 \times 10^{-7}$ grams per cubic meter.

3. Scale height [Literally, altitude of homogeneous atmosphere] at 200 kilometers over Fort Churchill during the day in the summer season was 95 kilometers; the maximum gradient of the scale of altitudes occurred in the upper region of the E layer and was equal to 2 kilometers per kilometer. ([See Note] La Gow, Horowits, Ainsworth, NRL)

4. The density of the upper atmosphere obtained by rocket sounding agreed well with provisional determinations of the density obtained by calculations of the orbit of the first Soviet satellite (1957 $\alpha$ 2). ([See Note] La Gow, Horowits, Ainsworth, NRL).

5. Measurements of the density of the atmosphere in the Arctic between 30 and 45 kilometers showed that seasonal and latitudinal changes in density are less than 15 percent; at the same time, pressure measurements made in the summer show that the temperatures and pressures are

markedly higher there than corresponding values at White Sands. ([See Note] L. DZhONS (L. Jones), Michigan University), (See Page 83).

6. Measurements of density made at of 49°, 58°, and 66° N. Latitude indicate marked latitudinal changes in density at 50 kilometers' altitude, approximately 2 percent per degree of latitude. ([See Note] STRAUD (Stroud), USASRDL).

7. Atmospheric temperatures over Fort Churchill, between 30 and 80 kilometers showed marked changes from winter to summer, reaching 20 degrees Centigrade at an altitude of 50 kilometers. ([See Note] Stroud).

8. In the summer, the temperature at an altitude of 80 kilometers above Fort Churchill was equal to 165 degrees Kelvin. ([See Note] Stroud).

9. The density of the atmosphere at an altitude of 150 kilometers above Fort Churchill at night in the winter season turned out to be $5 \cdot 10^{-7}$ grams per cubic meter when determined with a radio-frequency mass spectrometer. ([See Note] DZhONSON (Johnson), MEDOUZ (Meadows), KhOLMS (Holmes), TAUNSEND (Townsent), NRL).

10. The pressure, temperature, and density measured over Fort Churchill at an altitude of 30 - 90 kilometers generally yield smaller values than in lower latitudes. ([See Note] N. SPENSER (Spenser), BOGGS (Bogges), Michigan University and the Air Force).

In respect to the study of winds:

1. The winds in the upper atmosphere over Fort Churchill, between 30 and 80 kilometers, are from the east and weak in the summer; but are from the west and are very strong in the winter; a velocity equal to 150 meters per second was recorded at an altitude of 58 kilometers. ([See Note] Stroud).

In respect to photography at a great altitude:

1. The density of the atmosphere over Fort Churchill drops above the tropopause at a relatively faster rate than over White Sands, which is confirmed by scattering of light from the horizon from a greater altitude. ([See Note] BEKTOL (T. R. Bechtol), BRL).

2. The tropopause is clear-cut over Fort Churchill ([See Note] Bechtol).

1. Data obtained with an ultraviolet spectrograph at altitudes from 60 to 90 kilometers over New Mexico show that the concentration of nitric oxide cannot exceed $10^8$ molecules per square [Sic] centimeters. ([See Note] DZhURSA (Jursa), AFCRC).

2. Data obtained over Fort Churchill and based on three launchings in the winter and the spring, including daytime and night launchings, show that the nitric oxide content in the upper atmosphere is insignificant. ([See Note] Johnson, Meadows, Holmes, and Townsend, NRL).

3. Data obtained over Fort Churchill and based on three rocket launchings in the winter and spring, including daytime and night launchings, show that diffusion separation of argon and nitrogen takes place between 100 and 120 kilometers altitude, above which level the value of the ratio of $Ar/N_2$ decreases continuously with altitude. ([See Note] Johnson, Meadows, Holmes, and Townsend, NRL).

4. Air samples taken during two rocket launchings over White Sands in August 1956 indicated diffusion separation in an atmospheric layer from 60 to 90 kilometers. ([See Note] Jones, BARTMAN (Bartman), Michigan University).

5. As for the distribution of molecular oxygen at altitudes of 70 - 100 kilometers over Fort Churchill, the maximum difference of 2 kilometers in the altitudes of equal concentrations was observed between two launchings in the winter and in the summer. ([See Note] KUPPERIAN (Kupperian), BAYRAM (Byram), and FRIDMAN (Friedman), NRL).

In respect to study of the ionic composition:

1. Data obtained over Fort Churchill and based on three launchings in the winter and the spring, including daytime and night launchings, show that nitrogen oxide is the predominant source of positive ions in the ionosphere E-layer. ([See Note] Johnson, Meadows, Holmes, Townsend, NRL).

2. Data obtained over Fort Churchill as a result of three launchings in the winter and spring, including daytime and night launchings, show that atomic oxygen in the ionosphere E-layer yields primarily positive ions. ([See Note] Johnson, Meadows, Holmes, and Townsend, NRL).

3. It was established that as the altitude increased from 100 to 200 kilometers, the order of relative predominance of positive ions in the daytime changes from ($O_2^+$, $NO^+$) to ($NO^+$, $O_2^+$, $O^+$) and then to ($O^+$, $NO^+$, $O_2^+$). ([See Note] Johnson, Meadows, Holmes, and Townsend, NRL).

Z



In respect to the density of the ionospheric charge:

1. The distribution of electron density over Fort Churchill in the daytime turned out to be analogous to the distribution of electron density over White Sands in the daytime up to altitudes of 235 kilometers. ([See Note] SEDDON (Seddon), DZhAKSON (Jackson), NRL).

2. There was no divergence at all between the curves of electron density in the E- and F-layers over Fort Churchill in the daytime. ([See Note] Seddon, Jackson, NRL).

3. Electron densities of less than 2 x $10^4$ electrons per cubic centimeter were noted at altitudes of about 170 kilometers over Fort Churchill at night. ([See Note] Seddon, Jackson. NRL).

4. It was established that the fading of signals during polar nights was caused for the most part by pronounced absorption in the region of altitudes of 60 - 70 kilometers where the mean density of electrons was equal to 5 x 10 electrons per cubic centimeter. ([See Note] Seddon, Jackson, NRL).

5. The frequency of electron collisions in the 60 - 80 kilometer region turned out to be three orders lower than had been expected previously. ([See Note] Seddon, Jackson, NRL).

6. The condition known as scattering of reflections from the F-layer was observed at an altitude of 190 kilometers. The region turned out to be very turbulent and unstable. ([See Note] Seddon, Jackson, NRL).

In respect to solar radiation:

1. The spectrogram of the Sun which was obtained showed the helium-II line - 303 Angstrom units, the helium-I line - 584 Angstrom units, and the Lyman Series. ([See Note] RENZ (Rense), Colorado University).

2. Sun flares caused radiation of x-rays of quite great intensity and fairly short wave length, which explains the disruption of radio communications. ([See Note] Friedman, ChABB (Chubb), Kupperian, LINDSEY (Lindsay), NRL).

3. A maximum stream of solar x-rays was observed in the upper atmosphere during a maximum of sun spots and was equal to 1.0 ergs per centimeter per second. (See Note] Byram, Chubb, Friedman, Kupperian, UNTsIKER (Unzicker), NRL).

4. An image of the Sun in $L_\alpha$ rays indicates the presence of increased intensity of radiation in this part of the spectrum on the disk of the Sun. ([See Note] PERSELL (Percell), TAUSI (Towsey), NRL).

5. A sharply bounded image of the Mg-II Doublet was obtained at 2800 Angstrom units; the half-width of the line of radiation was approximately 0.4 Angstrom units, the absorption lines appeared to be separated in the maximum of the radiation bands, but shifted approximately 0.05 Angstrom units toward the larger wave lengths. (Bogges, Percell, Towsey, NRL).

In respect to luminescence of the atmosphere:

1. A continuous spectrum of the luminescence of the atmosphere was obtained in daylight in the region extending from 5600 to 6300 Angstrom units at altitudes between 60 and 90 kilometers by using photoelectric spectrometers. ([See Note] Jursa, AFCRC).

2. Radiation in the L [Lyman?] Region attained up to $10^{-2}$ ergs per square centimeters per second from all hemispheres. ([See Note] Kupperian, Chubb, Friedman, NRL).

In respect to the aurora borealis:

1. In one rocket flight into the region of the visible aurora borealis, the measured stream of radiation of atomic oxygen at 1300 Angstrom units in the ultraviolet region was equal to $1.5 \times 10^{-2}$ ergs/$cm^2$/line/sec. ([See Note] Byram, Friedman, Kupperian, Lindsay, Unzicker, NRL).

In respect to corpuscular radiations connected with the aurora borealis:

1. High-energy electrons in the upper atmosphere constitute the primary source of the luminescence of the aurora borealis and ionization. ([See Note] MEREDIT (Meredith), DEYVIS (Davis), NRL).

2. High-energy ions were found in the upper atmosphere in the zone of the aurora borealis, both outside the visible zone as well as inside it. ([See Note] Meredith, Davis, NRL).

3. Electric currents correlated with the visible aurora borealis were discovered at altitudes of more than 120 kilometers by measuring their magnetic fields. ([See Note] KhEPPNER (Heppner), Meredith, NRL).

4. Rocket launchings at Fort Churchill permitted making direct measurements in the visible aurora borealis of the absolute intensities and energy spectra (distribution according to energies) of electrons as well as of protons. ([See Note] MAK-ILVEYN (McIlwain), VAN-ALLEN (Van Allen), KEYKhILL (Cahill), SUI).

5. Measuring the aurora with Rockoon rockets in the Arctic and Antarctic Zones added to the knowledge of high-altitude distribution of soft radiation, its energy, and connection with the visible aurora. ([See Note] McIlwain, Van Allen, Cahill, NRL).

In respect to rocket astronomy:

Radiation from diffuse clouds were observed in the vicinity of the 1300 Angstrom units region of the spectrum. The energy of some sources of radiation exceeded $10^{-5}$ ergs/square centimeter/second$^2$/line. ([See Note] Kupperman, Friedman, Bogges, Milligan, NRL).

In respect to study of cosmic rays:

An overall study was made of the intensity of cosmic ray radiation over the atmosphere from Greenland to Antarctica, which showed:

a) There were marked latitudinal changes between 45 and 50 degrees of geographical latitude in both hemispheres;

b) The intensity of radiation was the same at high latitudes, north and south;

c) Polar values of the intensity could amount to about 60 percent of their total value when there was a minimum of sun spots. ([See Note] Van Allen, Cahill, NRL).

In respect to study of the magnetic field of the earth:

1. Detailed measurements of the earth's magnetic field were made up to altitudes of 120 kilometers by launching rockets equipped with proton precessional magnetometers in the Arctic zone of aurora borealis. The presence of a system of equatorial electrical currents was confirmed, and its latitudinal and longitudinal distribution was studied. ([See Note] Van Allen, Cahill, NRL).

## II. RESEARCH WITH ARTIFICIAL EARTH SATELLITES

### a) Scientific problems to be solved with the aid of satellites

It was stipulated in planning the research that several experiments should be set up for satellites. It was planned, first of all, to measure the intensity of solar radiation in the $L_\alpha$ region of the short-wave portion of the spectrum.

Experiments were also planned which would have the objective of studying the density of streams of meteors and the size of the particles composing them.

A great deal of attention was devoted in the program to study of cosmic radiation, both in respect to comparing it with solar and magnetic phenomena as well as in respect to study of the energy spectrum of primary cosmic rays and their intensity.

It was assumed that the density of the air at great altitudes could be determined and that data on the shape of the earth and gravitational anomalies could be obtained by observing the evolution of the orbits of satellites.

It was also planned to measure the skin temperatures of satellites at different points, also temperatures within satellites as they move along their orbits.

Along with these studies, it was planned to conduct experiments with satellites on direct measurement of the magnetic field of the earth, and to study its radiation balance and cloud cover.

In the initial program of research with artificial satellites, the United States made no plans at all to study the ionosphere by observing radio signals propagated in it by satellites. This is explained partially by the fact that the operational frequency of the radio transmitters in the American satellites -- 108 megacycles -- was selected due to the necessity of ensuring precise radio tracking of satellites which were of small size and could not be employed for that purpose.

Later, in connection with the results obtained from observing the radio signals from Soviet satellites, this decision was revised. According to a statement made by Dr. Porter at the time of the Fifth Assembly of the SK of the IGY, the United States would also launch a satellite in the future which would be designated specially for ionospheric research with a transmitter that would operate on a frequency on the order of 20 megacycles.

Prior to launching satellites designated for certain geophysical observations, it was planned to launch four small test spheres with radio transmitters (Figure 1). The spheres were to have a diameter of about 16 centimeters and to weigh about 1.8 kilograms apiece. Some of them were to be fitted with solar batteries. The purpose of these launchings was to test the transmitters operating on ordinary and on solar batteries, and also to measure certain physical parameters. The second satellite launched by the United States was called, as usual, the Vanguard, and was such a sphere and designated precisely for these purposes.

F50 b) Brief items of information on artificial satellites of the Vanguard Project

In order to carry out the research program with artificial satellites, the United States Naval Research Laboratory developed four satellites of the Vanguard type (Figure 2). Inasmuch as the satellites of this project have not been launched as yet, only a general description will be given of their construction and the research for which they were designated. ([See Note] A satellite of the Vanguard Project (Vanguard II or 1959 $\alpha$) was launched only in the beginning of 1959).

It was planned that the first satellites would have a spherical shape with a diameter of 50 centimeters and weigh about 10 kilograms apiece. All of them were to separate from the last stage of the carrier rocket.

The material of the skin of the satellite was to be magnesium. Its surface was to be well polished and covered with silicon monoxide. In order to protect the satellite from aerodynamic heating during flight, it was to be covered with a protective nose cone which should be cast off after 180 seconds of flight, after the rocket had left the upper layers of the atmosphere. Four structural designs were developed for the six satellites specified by the program. Solar radiation in the region of the $L\alpha$ line was to be studied by a special type of ionization chamber which would be sensitive only to radiation in the given region of the solar spectrum. It was planned to transmit information on instantaneous values of the intensity of the radiation. Moreover, the plans called for installing apparatus in the satellite for remembering and transmitting maximum values of radiation at the time of solar flares to the earth.

This was done with the objective of preserving observations made at times when the satellite would be far from receiving stations.

Measurements of the skin temperatures of the satellite and also temperatures within the instrument chamber were to be made by three thermistors located at suitable places of the structure. Measurements of the skin temperatures were to be made at the equator of the satellite and also at its poles.

Micrometerorite streams were to be studied by several methods. In the first place they had in mind the use of small erosion instruments installed on the outer surface of the satellite. Each was a thin film that would conduct electricity deposited on glass and which would permit discovery of damage to the sensitive element upon collision with small particles.

Another variant of these instruments was a register consisting of a photo cell covered with an opaque material which meteorite particles would scratch and wear. Then the photo cell would register the degree of damage to the covering and, perhaps, the intensity of the stream of meteors in time. It was also planned to register meteorites large enough to pierce the skin of the satellite. Control over the state of preservation of the skin would be achieved by measuring the pressure in two cavities of the satellite which would be hermetically sealed from each other.

There are still two more, probably later variants of the sensitive element for registering micrometeors. One of them is an impulse microphone which should react to small particles colliding with the skin of the satellite at any point. The second is a mesh arrangement made of thin wires connected in parallel. Jump changes in the resistance of the mesh would make it possible to judge breaks in the wires under the action of blows of sufficiently large meteoric particles.

The last two variants were carried out in the Explorer satellites.

The intensity of cosmic ray radiation was measured with a Geiger-Mueller counter.

Study of the radiation balance of the earth and its cloud cover was to be accomplished by a photoelectric apparatus operating in the infrared part of the spectrum. The Vanguard artificial satellite, which was to be launched on 16 September 1958 but whose launching was postponed for technical reasons, was designated especially for this part of the research (see the photo on page 88).

The satellites had four antennas located along the equator and placed relative to each other at a 90 degree angle. When the satellite was being sent into orbit they were folded and housed in the forward part of the body. After the protective nose cone was released they were forced into the working position by springs. Such an arrangement of the antennas should ensure a circular polarization of the radio signal, which would permit one to judge the proper rotation of the satellite with the aid of radio observers. This rotation could take place both due to its revolutions around the earth as well as due to external influences arising in the process of launching the satellite and in its movement along its orbit.

The actual fulfillment of this section of the IGY program was accomplished in 1958 with four Explorer satellites which are described below. Those sections of research which were not accomplished in Explorer satellites will apparently be realized in the future.

There are communiques in the American press to the effect that attempts to launch Vanguard satellites will be undertaken again in the beginning of 1959.

The American press also carries news items to the effect that after construction is completed on the new Vandenberg Range (on the West Coast of the United States, about 300 kilometers northwest of Los Angeles), the United States Air Force will use modified Thor and Atlas rockets to begin a new program for cosmic research which has the assigned name Discoverer. No data at all have been published on the character of this research; there is only a brief indication that the program will be large and will unify all types of research in cosmic space. There is also a communique to the effect that the program will include the launching of a meteorological satellite.

c) Brief items of information on artificial earth satellites launched in the United States

The first American satellite, the Explorer I (Figure 3), which has the arbitrary name 1958, was placed in orbit on 1 February 1958. It was launched at 3 hours, 55 minutes, and 5 seconds Greenwich Time from a point with approximate coordinates of 25° 50' N. Latitude and 73° 36' W. Longitude. The initial period of revolution of the satellite was 114 minutes 57 seconds, the height of the perigee of the orbit was 350 kilometers, the height of the apogee — 2,540 kilometers. The orbit was inclined at an angle of 33°35' to the equatorial plane.

([See Note] It is the custom in the foreign scientific literature to name a satellite by the year of launching, followed by a letter of the Greek alphabet which designates the order in which the given satellite was launched. Thus, the two Soviet satellites launched in 1957 have the designations 1957$\alpha$2 and 1957$\beta$. The carrier rocket of the first satellite was designated 1957$\alpha$1. In 1958 three American satellites were launched — 1958$\alpha$ (Explorer I), 1958$\beta$2 (Vanguard I), and 1958$\beta$1 — its carrier rocket, 1958$\gamma$ (Explorer III), the Soviet satellite 1958$\delta$2 — its carrier rocket 1958$\delta$1, and the fourth American satellite — 1958$\varepsilon$. The order in designating the carrier rockets and the satellites is caused by the fact that the carrier rockets have greater brightness than the satellites.)

The satellite was the last stage of the rocket, with the apparatus in the nose part. The total length of the satellite was about 2.4 meters, the diameter 15 centimeters, and the weight was 13.8 kilograms, of which the scientific apparatus accounted for about 5 kilograms.

The instruments located in the satellite were designed to measure and transmit four types of information to the earth: the hull temperatures, the temperatures inside the satellite, the erosion of the hull under the action of cosmic dust, and data on cosmic radiation. The main portion of the instruments consists of apparatus for studying cosmic radiation developed by Van Allen [1, 2] and a Geiger-Mueller counter.

A Microlock transmitting system was installed in the satellite, which had two transmitters, one of which operated on a frequency of 108.03 megacycles with a power of 60 milliwatts, and the second on a frequency of 108 megacycles with a power of 10 milliwatts. The power sources were two mercury batteries which weighted 680 grams each. The period of operation of the first transmitter was estimated to be 2 - 3 weeks, and the second -- 2 - 3 months. The estimated life of the satellite was planned to be 5 - 10 years.

The second Vanguard artificial satellite or 1958 $\beta$ 2, which was launched in the United States in accordance with the Vanguard program, a test sphere was placed in orbit on 17 March, (Figure 1). Its initial period of revolution around the earth was 2 hours, 14 minutes, and 4 seconds. The initial height of the perigee of the orbit was 648 kilometers, and the apogee was 3.940 kilometers. The inclination of the orbit to the equatorial plane was about 34 degrees.

The satellite was a sphere with a diameter of 16 centimeters and a weight of 1.8 kilograms. It carried out no scientific experiments at all except measurements of internal temperatures.

Apparently the principal purpose of the launching was to test the solar batteries installed in it. Two transmitters operating on frequencies of 108 and 108.03 megacycles were installed in the satellite. The first transmitter received its power from chemical batteries with a useful life of two weeks while the second received power from the solar batteries.

The leader of the Vanguard project, John Hagen, announced in his appearance before newspaper editors in May 1958, the estimated life of the second American satellite would be about 200 years.

The third stage of the rocket (1958 $\beta$ 1) which was separated from the satellite, was also in orbit. It was impossible to observe the satellite with the naked eye.

The third American satellite, the Explorer III (1958 $\gamma$) was placed in orbit on 26 March 1958. The initial period of revolution of the satellite around the earth was 115 minutes 54 seconds, the height of the perigee of the orbit was 187 kilometers (the launching was not wholly successful), and the apogee was 1,850 kilometers. Its orbit was inclined at an angle of 30° 30' to the equatorial plane.

The shape of this satellite was similar to that of the first (see Figure 3). Its weight was 12.4 kilograms. Apparatus for studying cosmic rays, and for transmitting temperatures and collisions with meteors was installed in it.



The satellite had two transmitters operating at the same frequencies as those used in the preceding satellites. The antenna was the body itself, divided into two parts by an annular insulator made of fiberglass. The power source was chemical batteries. There was a memory device in the satellite. The magnetic recording device, with a diameter of 63 millimeters, weighed 220 grams. The magnetic tape, which had a length of 92 centimeters and a width of 0.025 millimeters was made of a phosphor bronze alloy and coated with a film of cobalt. The operating speed of the tape was 4.5 millimeters per minute. It required 20 milliwatts to operate the tape and to wind up the rewind spring. The device did not record every pulse caused by cosmic particles striking the Geiger counter, but only every 128 pulses.

Thus, a total of several pulses per minute were recorded on the tape. The device which sent the recorded information to the earth was switched on by a signal from the earth. A special receiver was installed in the satellite for receiving the signal. Upon receipt of the signal, the accumulated information was transmitted within 6 seconds, then the magnetic tape was rewound by the spring to the starting position with simultaneous erasing of the recorded data.

The satellite burned up in the atmosphere on 28 July 1958.

It, too, was not visible to the naked eye.

The fourth American satellite, the Explorer IV, which also resembled the Explorer I, was placed in orbit on 27 July 1958. Its initial period of revolution about the earth was 110 minutes 12 seconds. The height of the perigee of the orbit was 262 kilometers, the apogee was 2,210 kilometers. The orbit was inclined at an angle of about 51 degrees with the equatorial plane. Thus, in contrast to the orbits of the preceeding satellites, it passed over the southern part of the Soviet Union.

The shape of the satellite and its dimensions were similar to the shape and dimensions of the first and third American satellites; it weighed 17.3 kilograms.

Apparatus was installed in the satellite for studying cosmic radiation of different intensities (with four supersensitive counters) and, in addition, two transmitters with power of 10 and 30 milliwatts, designed to transmit continuous signals for a period of two months at frequencies of 108 and 108.03 megacycles.

The estimated length of life for the satellite was about five years. It could not be seen with the naked eye.

The fifth artificial satellite was launched by the United States on 19 December 1958 from Cape Canaveral. Its orbit was inclined at an F
angle of 32 degrees to the equatorial plane. The launching was not on 5
the IGY program and no geophysical experiments at all were conducted 0
with the satellite.

d) Vehicles for launching and the orbits of the satellites

The satellites were launched from an experimental firing range on Cape Canaveral in Florida toward the southeast.

The first American satellite was launched with a four-stage Jupiter-C, the first stage of which was the Army liquid fuel Redstone rocket, and the three remaining were powder rockets. The toral length of the whole rocket was 21 meters, and the diameter of the first stage was 1.78 meters.

The fuel had the conventional name KHIDIN [Transliterated]. Liquid oxygen served as the oxidizer. The thrust of the engine was 34 tons.

The second stage consisted of 11 powder rockets which were a smaller variant of the Army Sergeant rocket, and the third was five rockets of the same type.

The fourth stage had a length of 2.4 meters. The scientific apparatus, power supply, and transmitters were housed in its nose portion. After the fuel was burned out, the fourth stage became an artificial earth satellite.

Communiques on the launching stated that the second, third, and fourth stages were all rotated together about the longitudinal axis of the first stage with an electric motor 70 seconds prior to the start. The speed reached 700 r. p. m. and was maintained through the active part of the trajectory. The rotation had the purpose of stabilizing the longitudinal axis of the rocket during flight. This was essential due to the conditions for placing the satellite in orbit, that is, to compensate for the effect of uneven burning of the fuel in the individual solid fuel rockets which comprised the second and third stages. It was stated that even the failure of one of the rockets would not prevent the satellite from being placed in orbit.

A pause was planned between the end of the operation of the motors of the third stage and the beginning of operation of the fourth. The instant for firing the fourth stage was determined with the aid of a terrestrial tracking apparatus as the system of orbiting was semiautomatic. The first stage lifted the satellite beyond the atmosphere and turned it parallel to the earth's surface. The remaining stages ensured the satellite of orbital velocity. The surface tracking system issued a command to fire the engine of the fourth stage at the instant that the satellite, which had maintained the position of its axis unchanged due to its rotation, had reached the peak of the path ensured it by the preceding stages.

The necessity for such a guidance system arose out of the fact that all stages of the rocket except the first were not controllable and also in connection with the impossibility of accurate preliminary calculation of the thrust of the powder rockets.

The Vanguard rocket, which was a development of the Viking rocket, was a three-stage ballistic controllable rocket. The first two stages were liquid fuel rockets, the third -- solid fuel. The total weight of the rocket was about 9000 kilograms. The minimum thrust of the first stage was 12,200 kilograms; its fuel was kerosene and its oxidizer was liquid oxygen. The feed system operated with a turbopump unit. The fuel of the second stage was dimethylhydrazine and the oxidizer was nitric acid; the fuel feed was operated by a pressure generator which fed helium under high pressure into the fuel tanks.

The second stage ensured that the satellite should go into orbit and started to drive it in a horizontal direction.

Guidance during flight was ensured by gymbal mounting of the engine and the presence of electro-hydraulic control devices which operated through a program mechanism. The instruments for flight guidance were concentrated in the second stage.

The third stage rocket was not controllable and ensured only boosting the satellite which had already been placed in orbit to the required speed. Stabilization of its flight was achieved by rotating the rocket about its longitudinal axis.

It was initially planned that the parameters of the orbits of the Vanguard satellites would be as follows:

1) nominal height of the orbit - 483 kilometers;

2) the initial, least height of the orbit - not less than 322 kilometers;

3) the maximum height of orbit - not more than 2,250 kilometers;

4) the angle of inclination of the orbit to the equator - 40 degrees ± 30'.

The materials received from the United States discussed possible orbits with different values for the initial velocity and angle of inclination from the horizontal at the initial instant and the size of permissable errors in placing the satellite in orbit. The effect of air resistance and anomalies in the distribution of gravitational forces on the orbit was also discussed. The effect of the "bulge" in the equatorial part of the earth on the orbit of the satellites would be smaller for them than for the Soviet satellites as the orbits of the American satellites had a smaller angle of inclination with the equatorial plane. ([See Note] This subject was set forth considerably more fully and earlier in works by Soviet scientists (Uspekhi fizicheskikh nauk [Progress in the Physical Sciences], September 1957).

The above characteristics of the launching vehicles, launchings, and orbits refer, as has been noted, to the Vanguard Project. The launching of this rocket was preceded by a large number of failures: on 21 September 1958 five launchings out of six were failures, but in one of them (17 September) the rocket was saved for further attempts. The American press indicated in some communiques that further attempts to launch satellites with the Vanguard rocket would be carried out in 1959. On 21 September they had five rockets for this purpose. Apparently the first four of them will carry spherical satellites weighing about 10 kilograms while the last will carry a satellite weighing over 25 kilograms.

The technique of launching the third and fourth American artificial satellites was wholly analogous to the launching of the first satellite. The small inclination of the orbit with the equatorial plane made placing in orbit easier, for in this case the satellite acquired an additional velocity on the order of 5 percent due to the rotation of the earth.

The fifth artificial satellite was launched by the United States with the Air Force Atlas intercontinental ballistic rocket, but as has been noted previously, this launching was not connected with the IGY program. The American press carried news items to the effect that in the future the Atlas and another, still uncompleted, intercontinental rocket, the Titan would be used extensively for carrying out geophysical and cosmic research.

e) Radiotelemetry of information

Descriptions of telemetric devices occupy a significant place in materials published in the United States on research with artificial earth satellites. Only a brief resume is presented here.

As already noted, the transmission of information should be continuous in some cases, and in others by program or on command from the earth. A separate transmission system whose transmitters operated with a carrier frequency of 108 megacycles was developed for each of the variants. According to the original plan, four types of transmission were designed. Continuous transmission of information with an 80-milliwatt transmitter was planned for the first type, which was connected with study of solar radiation. At the same time, the carrier frequency should be modulated by the audio frequency within the limits of 2.6 - 15 kilocycles. Both a continuously-acting telemetering apparatus and a 50-milliwatt programmed apparatus were designated for observing micrometeorites and the intensity of cosmic rays. Satellites designated for measuring the geomagnetic field were to be equipped with a continuously-operating transmitter operating on a frequency of 108 megacycles and a transmitter operating on a definite program at a frequency of 108.03 megacycles. The fourth type of telemetering apparatus was to be similar to the second but supplemented with a programmed transmitter.

The principal transmitters of the first and the second types were to be stabilized with quartz at 108 megacycles with a range of about 2 kilocycles, the transmitters of the third type were designed to receive frequency and temperature characteristics with very small changes in frequency in the range 108 megacycles ± 5 kilocycles.

The telemetering coding systems were developed in such a manner that information was transmitted by changing the length of pulses, their amplitudes, and the intervals between them. Each group of signals was to contain 16 pulses and intervals and thus ensure 48 channels of information. The planned assignment of channels of information for experiments set up to measure solar radiation was given in the QST Journal of January 1958 [3].

After the failures in the Vanguard Program, two sets of teletransmitters were developed (later used in the Explorer satellites) to transmit the results of measurements needed in the study of cosmic radiation. Each of them had two transmitters, one of which operated on the principal frequency of 108 megacycles while the other operated on the supplementary frequency of 108.03 megacycles. The first transmitter operated on a power of about 60 milliwatts, which would permit using batteries with a power reserve for two weeks. Four telemetering channels provided four rocket research at the symposium on the study of the upper layers of the atmosphere with rockets and satellites, which had been convened at the time of the Fifth Assembly of the SK of the IGY. Some results from this research are given below.

The temperature of the skin of the satellite and inside the satellite. For normal operation of the electronic equipment, it was essential that the temperature inside the satellite should not drop below -5 degrees Centigrade and not rise above 45 degrees Centigrade even though higher temperatures, even up to 80 degrees Centigrade, would not cause material harm to the apparatus.

The results from decoding the telemetered signals from the Explorer IV and the Explorer III showed that the temperature inside the instrument compartment (cylindrical part) varied from 0 to 35 degrees Centigrade and the temperature inside the nose cone varied from 5 to 40 degrees Centigrade. In the meantime, the temperature of different parts of the hull of the satellite varied from -25 degrees Centigrade to 75 degrees Centigrade.

Recording of micrometeorites was done in the Explorer I and the Explorer III. A microphone receiver installed in the Explorer I permitted registration of micrometeorites with a diameter of 4 microns and larger. The second instrument, which was also installed in the Explorer II, was a set of twelve wire receivers connected in parallel, each of which consisted of two layers of a grid of enamelled wire with a diameter of 10 microns. The instrument registered collisions with micrometeorites of about 10 microns and larger. Information on micrometeorites obtained from these instruments was transmitted by low-power transmitters on both the Explorer I and the Explorer II. It appears from the data of the United States Air Force Research Center in Cambridge (AFCRC) that all the wire receivers (with the possible exception of one) remained intact during the entire time that the scientific apparatus and the transmitters of the Explorer I were in operation. Data obtained from the Explorer III showed that up to 6 May 1958 not one of the instruments had been damaged. Between 22 hours 43 minutes on 6 May and 0.2 hours 32 minutes on 7 May (by mean Greenwich time), two instruments turned out to be short-circuited. This case was accompanied by an interesting series of events. Unstable operation of one of the telemetering channels of the low-power transmitter was observed on 8 and 9 May. No telemetered signals at all were received from this transmitter from 04 hours 15 minutes of 9 May. On 10 and 11 May the Minitrack stations received signals from the more powerful transmitter which was operating with stops, and after 11 May no more signals were received. Since the chemical batteries of the satellite were still far from being exhausted, and both radio systems were independent, it was assumed that these abnormalities were the consequence of damage to the two instruments and the satellite itself by meteors while the earth was passing through the Aquarid meteor stream whose intensity reached its maximum approximately 5 May. Moreover, it was noted that the transmitters of the first and second American satellites continued to operate normally at this time.

Some data was also reported at the symposium on the registration of micrometeorites on the American Vanguard satellite which failed to go into orbit at the end of May. Due to the short duration of the experiment (the satellite apparently did not complete a single full F50 revolution around the earth), however, the results from it were unreliable.

Registration of cosmic radiation. This most complete section of research with artificial satellites was fulfilled in the United States by J. Van Allen, G. H. Ludwig, E. C. Ray, and C. E. McIlwain. Important results were obtained with the $1958\alpha$ and $1958\gamma$ satellites. In a preliminary report on the results of research on cosmic rays accomplished with the $1958\alpha$ and $1958\gamma$ satellites, a dependence on the intensity of radiation on the altitude was noted in the California region during the first two weeks of February which agreed with extrapolated results from rocket research.

The presence of cosmic rays of very high intensity, up to 140 pulses per second, was reliably established at altitudes of more than 100 kilometers. Along with this, there were periods when the Geiger counter showed less than 128 pulses in 15 minutes.

The proposition was stated that this radiation was connected with the soft radiation discovered previously during rocket launchings into the zone of the aurora borealis. Apparently, it is also connected with magnetic storms. Approximate calculations also provide grounds for assuming that this radiation is sufficiently intense to cause heating of the upper atmosphere. According to some suggestions, the particles of this radiation are protons with energies on the order of 50 Mev.

The very intense cosmic radiation discovered at great altitudes agrees with the results obtained from Soviet artificial satellites with whose aid the so-called "terrestrial radiation" was discovered, which is, apparently, a product of secondary cosmic radiation held by the earth's magnetic field.

The conclusions drawn from this discovery were very important. Dr. Herbert York, who holds the post of scientific leader of the Pentagon, considers, in particular, that flight in cosmic space is possible apparently only from the polar regions since the zone which is comparatively free from this radiation extends approximately 20 degrees about the poles. The data obtained with the Explorer IV satellite indicate that the belt of strong radiation extends at least 2300 kilometers from the earth and its intensity is so great that space travellers would receive a lethal dose in just 10 hours flight at this altitude. At distances up to 500 kilometers from the earth, the intensity of this radiation is not great and flights at this altitude are possible.

Study of the density of the upper layers of the atmosphere. In the United States, the Vanguard Computing Center made calculations of the density of the upper layers of the atmosphere in accordance with data obtained from observations of the evolution of the orbits of the first Soviet satellite (1957 2), also the first and second American satellites (1958 and 1958 2). The results obtained (Figure 4) turned out to be in good agreement with the model of the atmosphere suggested by M. Nicolet Figure 5 shows the dependence of the temperature on the altitude and is based on the coincidence of the results obtained with the aid of observations of orbits with M. Nicolet's model and apparently corresponds with the actual temperatures at the corresponding altitudes.

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* In addition to the sources indicated above, use was made of official notices of launchings, material published in the American press, and also material set forth in reports by the American delegation at the Fifth Assembly of the SK of the IGY held in Moscow in August 1958, and others.

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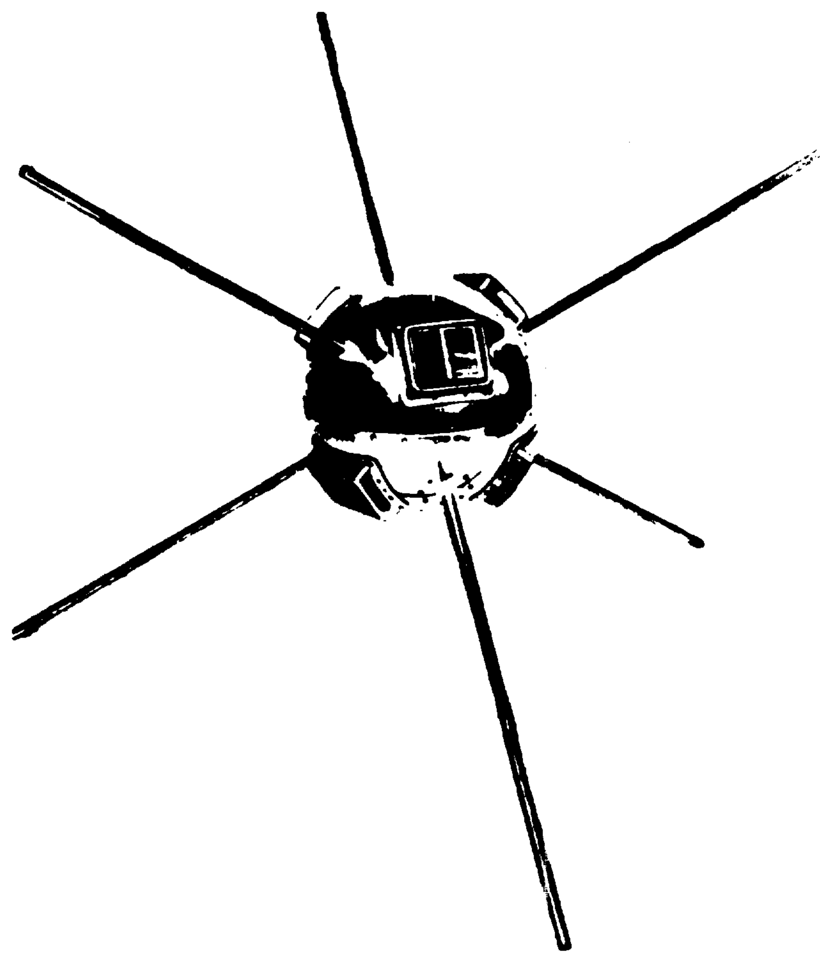

Figure 1.- The second American artificial earth satellite, the Vanguard test sphere, launched March 17, 1958.

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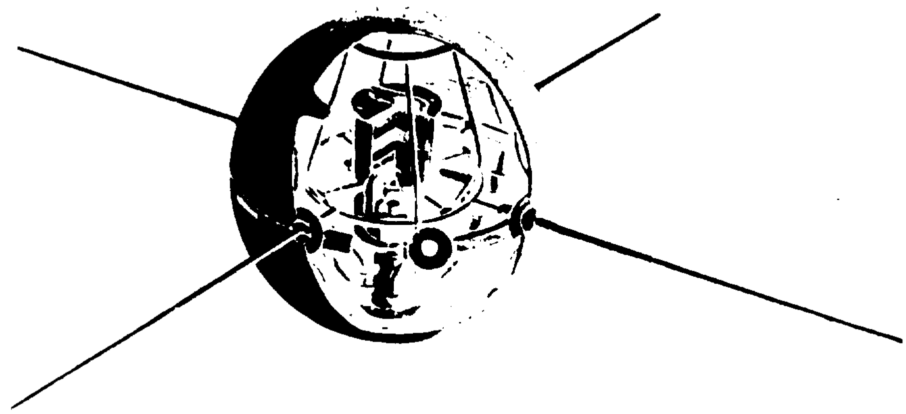
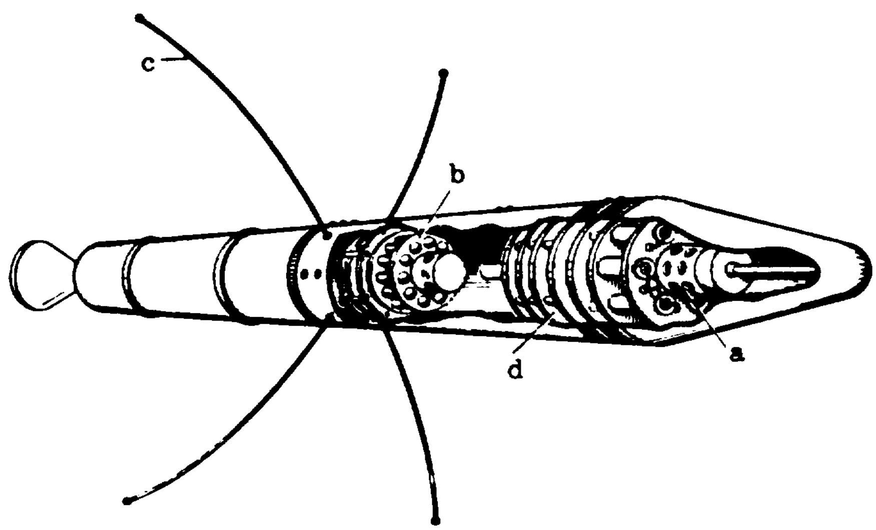


Figure 2.- A satellite of the Vanguard Project.




a - Low-power transmitter.
b - High-power transmitter.
c - Antenna.
d - Instruments for studying cosmic rays and micrometeorites.

Figure 3.- The first American satellite, Explorer I, launched February 1, 1958.

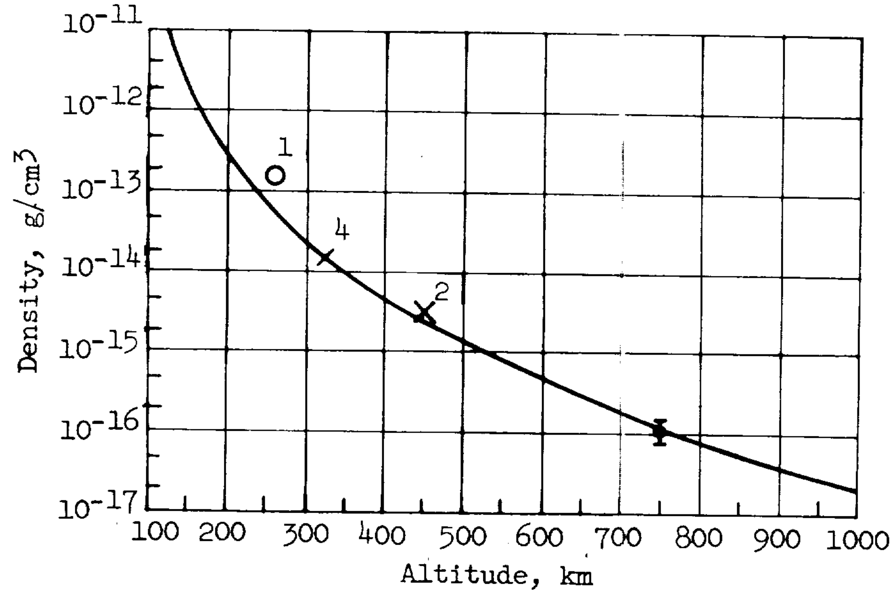



Figure 4.- Changes in density with altitude according to data from observations. 1 - from the first Soviet satellite (1957, α2); 2 - from the first American satellite (1958, α); 3 - from the second American satellite (1958, β2); 4 - according to the model of the atmosphere suggested by M. Nicolet.

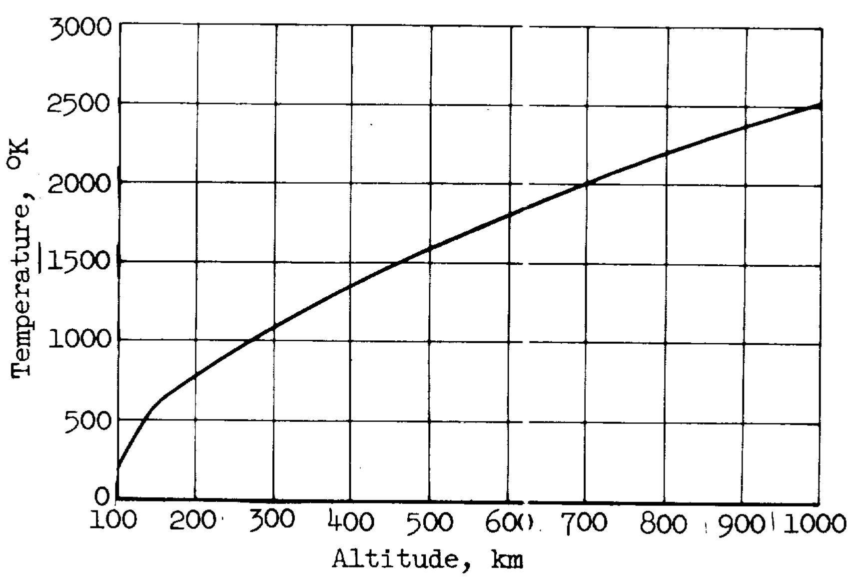



Figure 5.- Changes in temperature with altitude according to the model of the atmosphere suggested by M. Nicolet.